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Transport Corridors and Peripheral Urbanization in Telangana: Modelling the Influence of Highways and Regional Ring Roads on Land Use Transformation

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Abstract:
Transport corridors reshape the urban edge by altering accessibility, land rents, and the expectations that govern farmland conversion. This paper examines how highways and ring roads influence peripheral land-use transformation in Telangana, focusing on the Hyderabad region, where the 158-kilometre Outer Ring Road has operated for over a decade and a roughly 340-kilometre Regional Ring Road is being planned. Combining a framework drawn from location theory and the highway and urban-form literature with published remote-sensing evidence for 2005–2016, the study builds a spatially explicit scenario model of farmland-to-built-up conversion on a calibrated synthetic landscape. Three twenty-year scenarios are compared: a baseline without the Regional Ring Road, a Regional Ring Road with controlled access at interchanges, and a Regional Ring Road with open access. Holding aggregate demand constant, open access raises development within two kilometres of the alignment more than forty-fold relative to baseline, increases leapfrog development from 4.9 to 14.2 per cent of new built-up area, and fragments the urban fabric into smaller patches. Controlled access moderates, but does not eliminate, these effects. Corridor design, interchange spacing, and complementary land policy matter as much as road capacity. The paper concludes with planning recommendations and a research agenda for empirical validation.

Keywords: transport corridors; peripheral urbanization; Outer Ring Road; Regional Ring Road; land-use change; Hyderabad; Telangana; scenario modelling.

1. Introduction

Cities in the developing world are expanding outward faster than their populations are growing. A global meta-analysis of urban land expansion found that built-up land has generally grown faster than urban population, implying falling densities (Seto et al., 2011), and a global assessment projected continued declines in urban densities to 2050 (Angel et al., 2011). In much of Asia the resulting landscape is not a clean boundary between city and countryside but a broad belt of mixed agricultural and non-agricultural activity stretched along transport routes, which McGee (1991) termed *desakota*. Highways and ring roads

are among the most powerful forces shaping that belt, because they change where land is cheap to reach and therefore where it becomes valuable to convert.

Telangana offers a timely case. The state was formed in 2014 and, according to the 2011 Census, was roughly two-fifths urban, with the Hyderabad urban area holding about 7.7 million people (Hyderabad Metropolitan Region, n.d.; Office of the Registrar General & Census Commissioner, India, 2011). The Hyderabad Metropolitan Development Authority now has jurisdiction over approximately 10,473 square kilometres spanning eleven districts (Hyderabad Metropolitan Region, n.d.). Remote-sensing work for 2005–2016 shows that the built-up area of the Hyderabad study region roughly doubled, from about 38,863 hectares to 80,111 hectares, while rain-fed cropland roughly halved, and the authors note that sprawl was expanding beyond the Outer Ring Road even though that road had been planned to regulate traffic (Gumma et al., 2017).

Two corridor systems frame the present debate. The first is the Outer Ring Road (ORR), an eight-lane, access-controlled expressway of about 158 kilometres commissioned in phases between 2008 and 2016 (Outer Ring Road, Hyderabad, n.d.). The second is the proposed Regional Ring Road (RRR), a roughly 340-kilometre greenfield expressway planned about 30 kilometres beyond the ORR under the Bharatmala Pariyojana programme (The Metro Rail Guy, n.d.). Proponents expect the RRR to decongest the core, decentralise industry, and seed new growth centres. Sceptics warn of speculative land markets, loss of productive farmland, and the costly provision of services to scattered development. Both positions rest on assumptions about how corridors translate into land conversion, assumptions that have rarely been made explicit or tested before a road is built.

The literature on highways and urban form is large, but three gaps are relevant here. First, most rigorous evidence comes from North America and China, while evidence on Indian metropolitan peripheries is thinner and mainly descriptive. Second, studies of Hyderabad document sprawl well but seldom isolate the corridor mechanism from general metropolitan growth. Third, planning debates tend to treat the design of a ring road, particularly its access regime, as secondary to its alignment, although theory suggests that access design governs where accessibility gains actually capitalise into land value.

This paper addresses three research questions. What does published evidence show about corridor-linked land conversion in the Hyderabad region between 2005 and 2016? How would alternative access regimes on the proposed RRR redistribute land conversion across space over a twenty-year horizon? Which planning levers appear to moderate the outcomes? To answer them, the paper develops a conceptual framework, assembles secondary evidence on the ORR and RRR, and builds a spatially explicit scenario model calibrated to published aggregate figures. The model is a controlled experiment on a synthetic landscape rather than a forecast, a distinction that is maintained throughout.

The paper proceeds as follows. Section 2 reviews the literature and sets out propositions. Section 3 describes the corridor network. Section 4 explains the data and model. Section 5 presents results, Section 6 discusses them, Section 7 draws policy implications, Section 8 states limitations, and Section 9 concludes.

2. Literature Review and Conceptual Framework

2.1 Highways, land rent, and urban form

Classical location theory provides the starting point. Von Thünen (1966) showed that land use around a market is organised by transport cost, and Alonso (1964), Mills (1967), and Muth (1969) extended the

logic to cities, in which bid rents decline with distance from the centre. When transport costs fall, the rent gradient flattens and urban land use pushes outward. A new expressway is therefore predicted to lower the cost of living far from the centre, but only for locations that can actually reach it. Redding and Turner (2015) review how such transport cost reductions reorganise economic activity across space.

Empirical studies support the direction of these predictions. Baum-Snow (2007) found that each new highway passing through a central city in the United States reduced its population by roughly one-fifth, evidence that highways cause suburbanisation rather than merely accompanying it. Duranton and Turner (2012) showed that metropolitan areas with more highways grew faster in employment, with measurable effects over twenty years. Banerjee et al. (2020) reported that proximity to transport lines in China was associated with higher income levels but not clearly higher growth, a reminder that corridor effects are spatially concentrated and uneven.

2.2 Peripheral urbanization in India

Indian evidence points in a similar direction but with distinct institutional features. Ghani et al. (2016) found that the Golden Quadrilateral highway programme shifted the location of manufacturing activity and improved performance in districts along the corridors, particularly in areas outside the main nodes. Asher and Novosad (2020) found that rural roads had limited effects on local incomes, mainly shifting workers out of agriculture, which suggests that the benefits of connectivity depend on complementary conditions. Ellis and Roberts (2016) argued that South Asia's urbanisation is often unplanned and dispersed, with weak links between land, infrastructure, and planning.

Within this setting, peripheral land conversion is shaped by market and institutional frictions. Brueckner (2000) identified three market failures behind excessive sprawl: the unpriced value of open space, the unpriced cost of congestion, and the failure of developers to bear the full cost of new infrastructure. Each is relevant at Hyderabad's edge, where farmland is converted for housing, logistics, and industry, and where service provision follows rather than precedes development. Measuring such change requires careful remote-sensing practice (Bhatta, 2010), and modelling it requires an explicit treatment of drivers, demand, and allocation (Verburg et al., 2004). Anas et al. (1998) add that cities increasingly develop as polycentric systems, in which new nodes on ring corridors compete with the old centre.

2.3 Conceptual framework and propositions

Figure 1 synthesises these strands. Corridors generate accessibility gains and trigger land-rent and expectation effects. These raise the probability of conversion for farmland nearby, which in turn shapes spatial form, whether compact nodes, continuous ribbons, or scattered leapfrog development, and ultimately outcomes such as farmland loss, fragmentation, and the cost of providing services. Moderators, including interchange spacing, access control, and zoning, and initial conditions, including distance to the city, soils, and water bodies, condition each link.

Figure 1

Conceptual framework linking transport corridors to peripheral land-use transformation

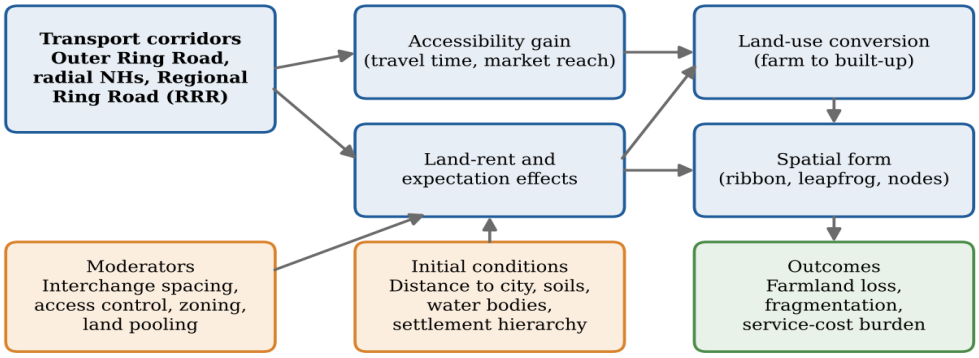


Figure 1 draws on location theory (Alonso, 1964; Mills, 1967) and empirical evidence on highways and urban form (Baum-Snow, 2007; Duranton & Turner, 2012).

Source: Author's conceptual framework, adapted from Alonso (1964), Mills (1967), Baum-Snow (2007), and Duranton and Turner (2012).

Three propositions follow and guide the model. Proposition 1 holds that the probability of farmland conversion declines with distance from a corridor, with the steepest gradient immediately beside the alignment. Proposition 2 holds that where access is restricted to interchanges, conversion concentrates around interchange nodes and decays more slowly with distance from the road itself. Proposition 3 holds that open access, in which the alignment is reachable along its whole length, produces more ribbon and leapfrog development and more fragmented built-up patches than controlled access.

3. Study Area: Telangana's Corridor Network

3.1 The Hyderabad region

The Hyderabad Metropolitan Region covers about 10,473 square kilometres, of which the continuous urban area is about 1,226 square kilometres (Hyderabad Metropolitan Region, n.d.). Its growth has been led by information technology and services in the west, by industry in the east, and by logistics and real estate along the radial national highways. Gumma et al. (2017) report that the strongest expansion between 2005 and 2016 occurred in the western and eastern zones, and that seasonal water bodies were among the land types most heavily converted. The region is served by radial national highways, including NH-44, NH-65, NH-163, and NH-765, which converge on the city and are linked by the ORR (Outer Ring Road, Hyderabad, n.d.). Figure 2 sketches this corridor structure.

3.2 The Outer Ring Road

The ORR is an eight-lane, fenced, access-controlled expressway of about 158 kilometres, designed for 100 kilometres per hour and later permitted at higher speeds (Outer Ring Road, Hyderabad, n.d.). Table 1 shows that it opened in six stages. Most of the length was in service by 2012, with later sections completing the ring. Figure 3 plots cumulative length. The ORR connects the IT corridor, the international airport, and the Genome Valley research cluster, and it was conceived to anticipate satellite townships beyond the municipal boundary.

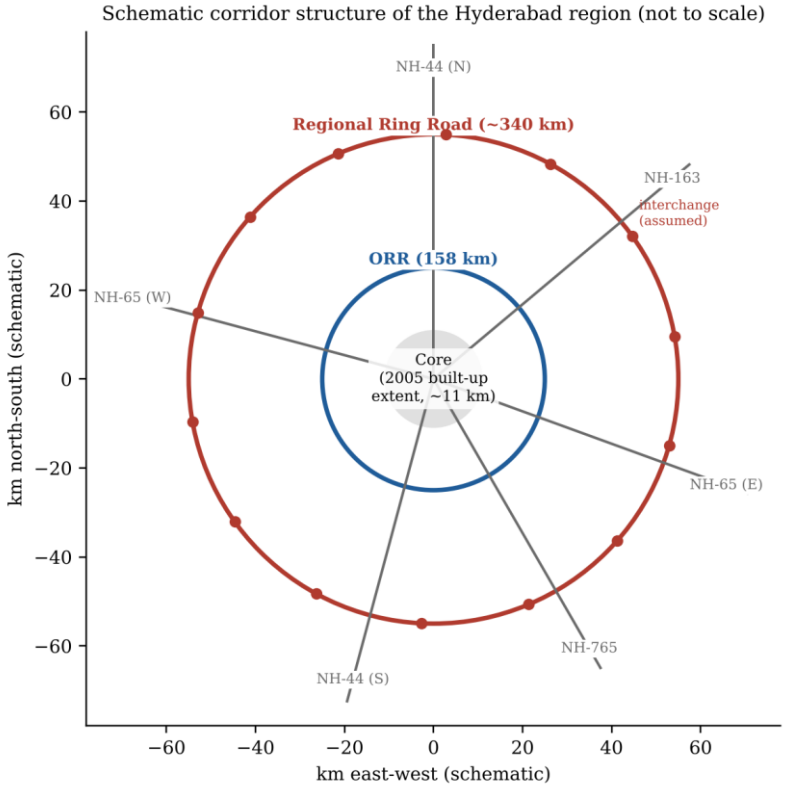
Table 1

Phased commissioning of the Hyderabad Outer Ring Road

Opening date	Section	Length (km)
14 Nov 2008	Gachibowli–Narsingi–Shamshabad	22.0
7 Jul 2010	Shamshabad–Pedda Amberpet	38.0
14 Aug 2011	Narsingi–Patancheru	23.7
3 Dec 2012	Patancheru–Gowdavalli; Kandlakoya–Shamirpet (part)	38.0
4 Mar 2015	Pedda Amberpet–Ghatkesar	14.0
15 Jul 2016	Ghatkesar–Shameerpet	23.0
	Total (sum of sections)	**158.7**

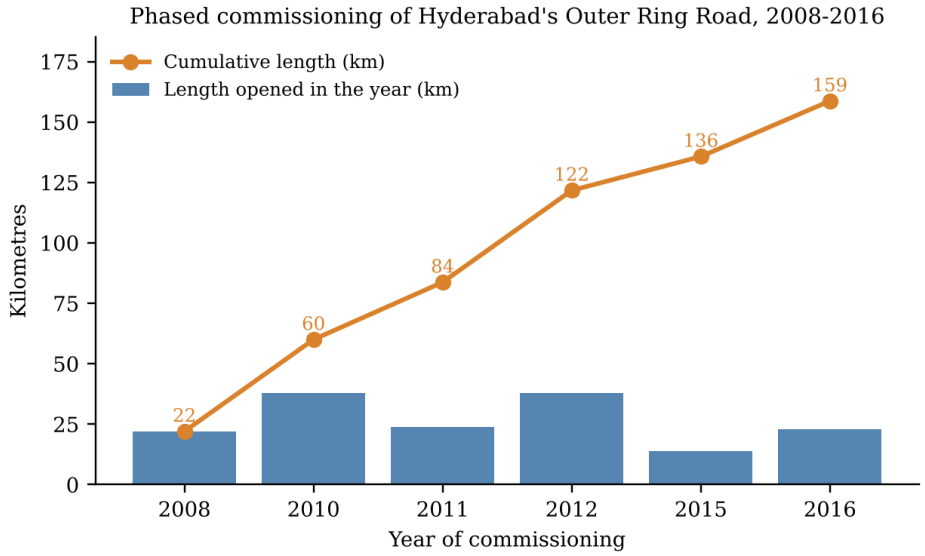
Note. Lengths are as reported in the source; parts of the Kandlakoya–Shamirpet section were completed later. Source: Outer Ring Road, Hyderabad (n.d.).

Figure 2- *Schematic corridor structure of the Hyderabad region*



Note. Not to scale; radial highway bearings and interchange positions are approximate and assumed for modelling. Source: Author's schematic based on Outer Ring Road, Hyderabad (n.d.) and The Metro Rail Guy (n.d.).

Figure 3- *Phased commissioning and cumulative length of the Outer Ring Road, 2008–2016*



Source: Author's calculation from section lengths in Outer Ring Road, Hyderabad (n.d.).

3.3 The proposed Regional Ring Road

The RRR is planned as a four-lane, access-controlled greenfield expressway, subject to the detailed project report, running about 30 kilometres beyond the ORR (The Metro Rail Guy, n.d.). Its northern section of roughly 164 kilometres would serve towns such as Sangareddy, Gajwel, and Bhongir, while its southern section of roughly 182 kilometres would pass Chevella, Amangal, and Ibrahimpatnam before rejoining at Choutuppal (The Metro Rail Guy, n.d.). Reported cost estimates range from about ₹16,000 crore to ₹17,000 crore, with the state expected to share land acquisition costs (NBM&CW, n.d.; The Metro Rail Guy, n.d.). Table 2 summarises its main attributes. At the time of writing the project is at the planning and land-acquisition preparation stage, which is precisely when design choices on access remain open.

Table 2- *Key attributes of the proposed Hyderabad Regional Ring Road*

Attribute	Description (as reported)
Total length	About 340 km
Northern section	About 164 km: Sangareddy, Narsapur, Toopran, Gajwel, Yadadri, Bhongir, Choutuppal
Southern section	About 182 km: Choutuppal, Ibrahimpatnam, Kandukur, Amangal, Chevella, Shankarpally, Sangareddy
Offset from ORR	Roughly 30 km
Configuration	Four-lane, access-controlled greenfield expressway (subject to DPR)
Programme	Bharatmala Pariyojana Phase-I
Estimated cost	About ₹16,000–17,000 crore (reports vary)
Principal connections	NH-44, NH-65, NH-765, and state highways

Note. DPR = detailed project report. Figures are planning-stage estimates and may change. Source: The Metro Rail Guy (n.d.); NBM&CW (n.d.).

4. Data and Methodology

4.1 Research design

The study uses a two-part design. The first part synthesises published evidence on corridor structure and on land-use change in the Hyderabad region between 2005 and 2016. The second part is a spatially explicit scenario model, a stylised land-conversion simulation that allocates a fixed quantity of new built-up land across a landscape under alternative corridor regimes. Because multi-temporal classification of the full corridor system lies beyond the scope of a single paper, the model is calibrated to published aggregates rather than to pixel-level observations. The model therefore tests whether corridor mechanisms drawn from theory generate plausible spatial patterns, and it compares regimes on a like-for-like basis.

4.2 Secondary evidence base

Evidence on land-use change comes from Gumma et al. (2017), who combined IRS-P6, Landsat-8, and MODIS imagery with ground surveys to map the Hyderabad region in 2005, 2011, and 2016, reporting map accuracy of 80–85 per cent. Their figures for built-up land, rain-fed cropland, and wastewater-irrigated area anchor the calibration. Corridor attributes come from the sources cited in Section 3.

4.3 Scenario model

The model represents a 150-kilometre square region as 300 by 300 cells of 500 metres, so each cell is 25 hectares. A smoothed random field marks about 14 per cent of cells as non-developable land, representing water bodies, forest, and rocky terrain. The city centre lies at the origin. The ORR is represented as a ring of 25-kilometre radius, consistent with a circumference of about 158 kilometres. The RRR is a ring of 55-kilometre radius, consistent with a position about 30 kilometres beyond the ORR and a length of about 340 kilometres. Six radial rays stand for the national highways, and fourteen interchange nodes, spaced about 25 kilometres apart, are assumed on the RRR.

Each year, undeveloped and developable cells are ranked by a latent utility, and the highest-ranked cells are converted until annual demand is met. Utility combines logged distances to the centre, the ORR, the nearest radial highway, and, depending on the scenario, the RRR, together with the built-up share in a five-by-five cell neighbourhood and a Gumbel random term. This is similar in spirit to a logit allocation of demand across cells (Hosmer et al., 2013) and follows the logic of demand-driven allocation models such as CLUE-S (Verburg et al., 2002). Table 3 lists the specification.

Table 3- *Specification of the scenario model*

Component	Operationalisation	Coefficient
Distance to city centre	ln(1 + km)	−0.9
Distance to ORR ring	ln(1 + km)	−0.7
Distance to radial highway	ln(1 + km)	−0.5
Neighbourhood built-up share	Share built-up in 5 × 5 window	+2.5
Distance to RRR (S2 only)	ln(1 + km from alignment)	−0.8
Distance to RRR interchange (S1 only)	ln(1 + km from nearest node)	−0.8
Random term	Gumbel, scale 0.6	—
Non-developable land	Excluded from allocation	—

Note. Coefficients are assumed, illustrative values set to produce plausible distance decay; they are not estimated from imagery. S1 additionally protects cells within 0.5 km of the alignment.

4.4 Calibration, scenarios, and indicators

The 2005 landscape is initialised with 38,863 hectares of built-up land. Between 2005 and 2016 the baseline model adds land until 80,111 hectares is reached, matching Gumma et al. (2017). From this calibrated 2016 state, three scenarios run for twenty years with annual demand set at 3 per cent of the existing built-up stock, which yields 64,550 hectares of new built-up land in every scenario. Scenario S0 is the baseline with the ORR and radial highways only. Scenario S1 adds the RRR with access only at interchange nodes and a protected strip along the alignment. Scenario S2 adds the RRR with open access along its full length. Holding demand constant isolates the spatial allocation effect, although it understates induced demand, which is discussed in Section 8.

Each scenario is replicated twenty times with different random seeds, and results are reported as means with standard deviations. Indicators include new built-up area within two kilometres of the RRR alignment, the share of new development beyond the ORR, the leapfrog share, the number and mean size of built-up patches, and conversion probability by distance from the RRR. A conversion is classed as leapfrog when no built-up cell lies within its five-by-five neighbourhood at the time of conversion. Full validation against classified imagery is left to future work using allocation and quantity disagreement measures (Pontius & Millones, 2011).

5. Results and Analysis

5.1 Historical evidence, 2005–2016

Table 4 reproduces the reported land-use changes. Built-up land increased by about 41,248 hectares, an increase of 106 per cent, while rain-fed cropland fell by about 34,915 hectares, a decline of 48 per cent. Wastewater-irrigated area along the Musi river expanded by about 5,020 hectares, or 32 per cent, as peri-urban farmers responded to urban demand for vegetables and fodder (Gumma et al., 2017). The authors

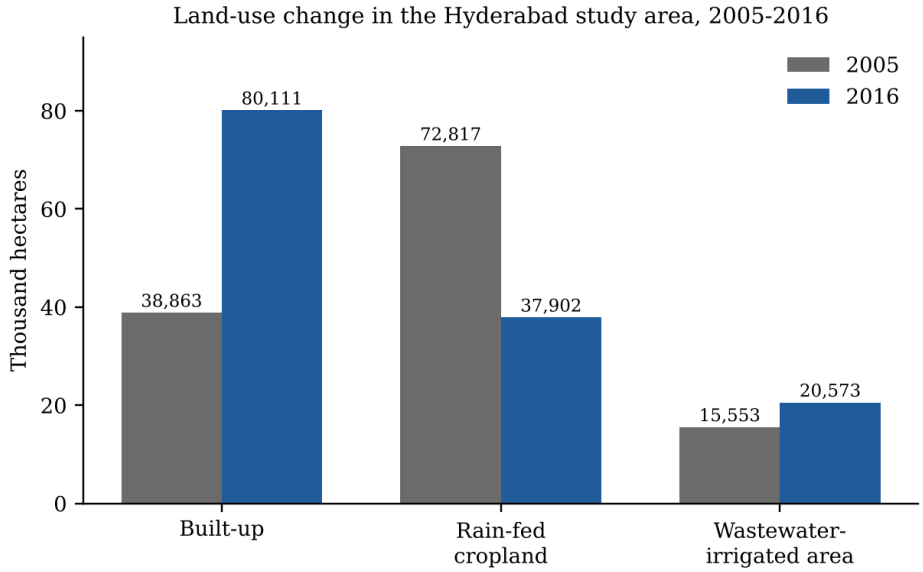
estimate that about 11,760 hectares of agricultural land was lost to urban growth, which they describe as irreversible, and that production pressure shifted to surrounding areas. Figure 4 summarises these shifts.

Table 4- *Reported land-use change in the Hyderabad study area, 2005–2016*

Land-use class	2005 (ha)	2016 (ha)	Change (ha)	Change (%)
Built-up	38,863	80,111	+41,248	+106.1
Rain-fed cropland	72,817	37,902	−34,915	−47.9
Wastewater-irrigated area	15,553	20,573	+5,020	+32.3

Note. Change columns are calculated by the author from reported areas. Source: Gumma et al. (2017).

Figure 4- *Land-use change in the Hyderabad study area, 2005 and 2016*



Source: Author's chart based on data reported in Gumma et al. (2017).

Two features of this evidence matter for the corridor question. The ORR was built in the same period (Table 1), and the study reports sprawl extending beyond it, which is consistent with Proposition 1: a corridor that improves accessibility pulls development to its margins and beyond. At the same time, the evidence cannot separate the ORR effect from the effect of IT and real-estate growth, which is why a controlled model experiment is useful.

5.2 Scenario outcomes

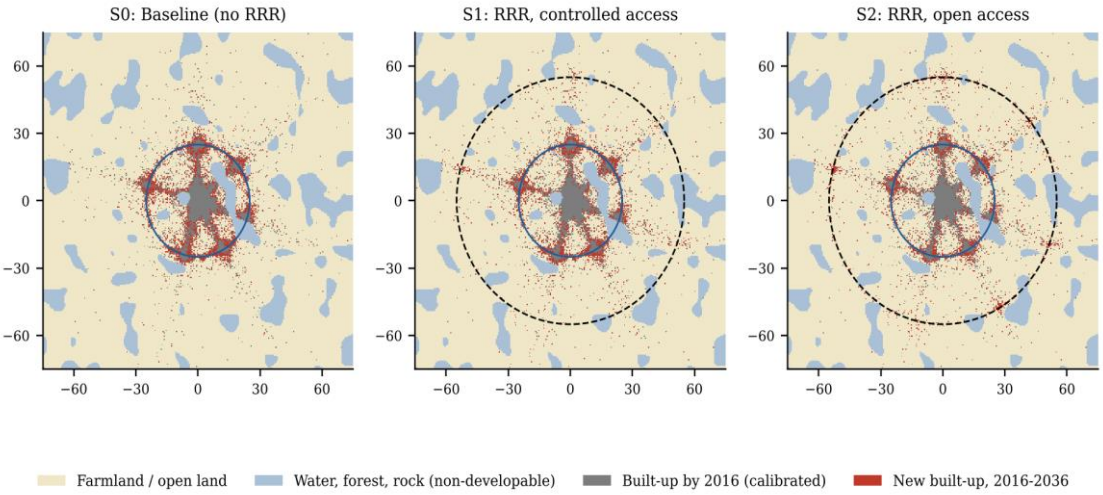
Table 5 compares the three scenarios. Because demand is fixed, total new built-up area is identical at 64,550 hectares and total built-up land reaches about 144,675 hectares by 2036, an increase of 81 per cent over 2016. What differs is where development occurs. In the baseline, only about 196 hectares of new development falls within two kilometres of the RRR alignment, which does not exist in this scenario. Under controlled access this rises to about 1,863 hectares, and under open access to about 9,069 hectares, roughly forty-six times the baseline.

Table 5- *Scenario results after twenty years of simulated growth (means of 20 replications)*

Indicator	S0 Baseline	S1 Controlled	S2 Open access
New built-up land (ha)	64,550	64,550	64,550
New built-up within 2 km of RRR (ha)	196 (76)	1,863 (316)	9,069 (999)
New built-up beyond ORR + 2 km (%)	21.8 (1.7)	37.2 (2.1)	46.8 (2.4)
Leapfrog share of conversions (%)	4.9 (0.6)	10.9 (0.8)	14.2 (0.7)
Number of built-up patches	1,215 (41)	1,534 (62)	1,726 (58)
Mean patch size (ha)	119.3 (4.1)	94.5 (3.8)	83.9 (2.8)
Cropland loss within 5 km of RRR (%)	0.2 (0.04)	1.6 (0.2)	4.6 (0.3)

Note. Standard deviations across replications are in parentheses. Results are synthetic scenario outputs, not forecasts. Source: Author's simulation.

Figure 5- *Simulated land use by 2036 under three scenarios (single replication)*



Note. Solid ring = ORR; dashed ring = RRR (S1 and S2 only). Axes show kilometres from the city centre. Source: Author's simulation on a synthetic landscape.

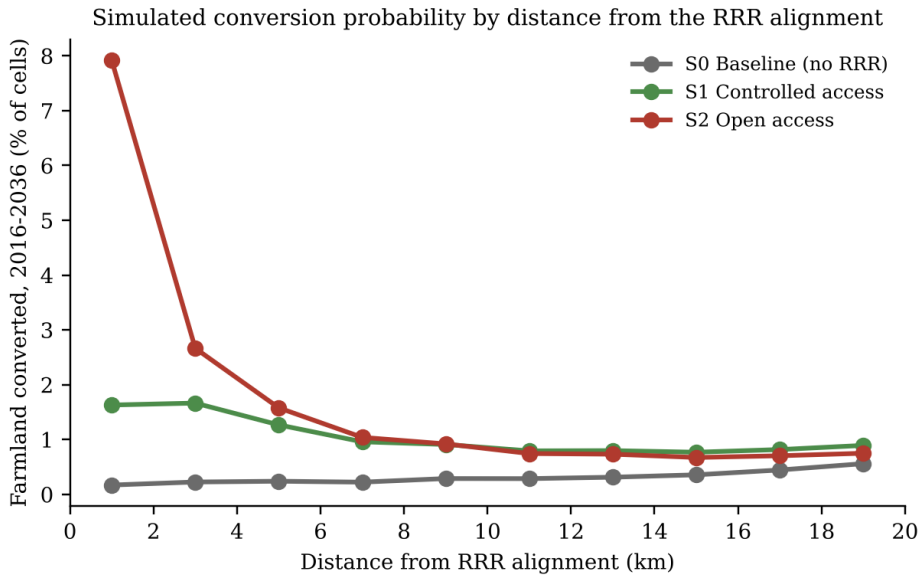
Figure 5 shows the spatial consequence. In the baseline, new development clusters along the ORR and the radial highways, with a thin scatter beyond. With a controlled-access RRR, scattered clusters appear around interchange nodes. With open access, development is also drawn to stretches of the RRR between nodes, producing a visible ring of dispersed settlement at 55 kilometres from the centre.

5.3 Distance decay around the Regional Ring Road

Figure 6 plots the share of 2016 farmland converted by distance from the RRR alignment. Conversion probability falls with distance in all scenarios, and the gradient is steepest under open access. In the first two kilometres, about 7.9 per cent of farmland is converted under S2, compared with about 1.6 per cent under S1 and 0.2 per cent in the baseline. Beyond about ten kilometres the curves converge at 0.7–0.9 per

cent in S1 and S2, still well above the baseline range of 0.3–0.6 per cent, which reflects the gentle pull the new ring exerts across the intermediate belt. This pattern supports Propositions 1 and 2.

Figure 6- *Simulated farmland conversion probability by distance from the RRR alignment*



Note. Bins are two kilometres wide; values are means of 20 replications. Source: Author's simulation.

5.4 Spatial redistribution and fragmentation

Table 6 shows how the RRR reallocates growth across distance bands from the centre. In the baseline, about 63 per cent of new built-up land lies within 25 kilometres of the centre and only about 4 per cent lies beyond 40 kilometres. Under controlled access the share beyond 40 kilometres rises to about 16 per cent, and under open access to about 29 per cent. The intermediate band of 40–60 kilometres, which contains the RRR, shows the largest change, from about 1,879 hectares to 17,234 hectares under S2.

Table 6- *Simulated new built-up land by distance from the city centre, 2016–2036 (hectares)*

Distance band	S0 Baseline	S1 Controlled	S2 Open access
Up to 25 km	40,431 (62.6%)	30,881 (47.8%)	26,036 (40.3%)
25–40 km	21,609 (33.5%)	23,483 (36.4%)	19,711 (30.5%)
40–60 km	1,879 (2.9%)	8,671 (13.4%)	17,234 (26.7%)
Beyond 60 km	631 (1.0%)	1,515 (2.3%)	1,569 (2.4%)
Total	**64,550**	**64,550**	**64,550**

Note. Percentages show the share of new built-up land in each scenario. Source: Author's simulation.

Fragmentation rises in step. The number of built-up patches increases from about 1,215 in the baseline to 1,534 under S1 and 1,726 under S2, while mean patch size falls from about 119 hectares to 94 and 84 hectares. The leapfrog share more than doubles under S1 and nearly triples under S2. These results support Proposition 3: the same quantity of growth is spread more thinly and less contiguously when the corridor can be accessed along its whole length.

6. Discussion

The results reproduce, in a controlled setting, the main mechanism proposed by location theory. Because the RRR lowers the cost of reaching distant locations, it flattens the rent gradient and pulls a share of growth outward (Alonso, 1964; Mills, 1967). The model does not create new demand, yet the redistribution alone is large: the share of new development beyond 40 kilometres of the centre rises from about 4 per cent to as much as 29 per cent. This is consistent with the empirical finding that highways reshape the location of population and employment (Baum-Snow, 2007; Duranton & Turner, 2012).

The comparison between S1 and S2 is the paper's most policy-relevant result. Controlled access with a protected strip reduces development within two kilometres of the alignment by about 80 per cent relative to open access, cuts the leapfrog share, and preserves larger contiguous patches. Interchange nodes still attract development, but they do so at discrete, plannable locations. This echoes the logic of Brueckner (2000): when the cost of scattered development is borne by the public, instruments that channel growth towards locations where services can be provided efficiently improve outcomes. It also resonates with the desakota literature, in which unplanned development along open corridors produces the mixed, fragmented landscapes that are hardest to serve (McGee, 1991).

The historical evidence adds a caution. The ORR is access-controlled, yet sprawl has extended beyond it (Gumma et al., 2017). Access control governs where vehicles may enter a road but not where developers may build, so land beyond the interchanges remains exposed to speculative conversion through feeder roads. This suggests that access control is a necessary but insufficient condition for orderly growth, and that regulation of the surrounding land market is equally important.

The distributional implications deserve attention. The farmland converted along a ring road is not an abstract quantity; it belongs to households whose livelihoods, tenure security, and bargaining power vary widely. Evidence from the Hyderabad region shows that peri-urban farmers adapt, for example by shifting to wastewater-irrigated vegetables and fodder (Gumma et al., 2017), but such adaptation depends on proximity to urban markets and continued access to land. Where small and marginal holders sell early at modest prices, later uplift may be captured by buyers and intermediaries. A corridor regime that concentrates development at a few planned nodes limits the number of landholders exposed to such pressure, while an open-access regime spreads uncertainty across a far larger area.

The findings also qualify the optimistic reading of ring roads as drivers of balanced regional development. A polycentric structure, in which nodes on the ring complement the core, is a plausible outcome (Anas et al., 1998), but in the model it emerges only when growth is directed to a limited number of nodes. Without that direction, the same investment yields dispersed settlement. Evidence from the Golden Quadrilateral suggests that corridors can support manufacturing outside the main cities (Ghani et al., 2016), yet evidence from rural roads shows that benefits depend on complementary conditions (Asher & Novosad, 2020). By extension, the RRR's developmental payoff is likely to depend on land, utility, and skills policy at least as much as on the pavement.

Finally, the results should be read for what they do and do not show. They show that, under a transparent set of assumptions drawn from theory, the access regime alone is sufficient to change the spatial pattern of conversion substantially. They do not show how much additional growth a regional ring road would induce, how land markets in specific mandals would respond, or whether planned nodes would attract the firms and households needed to fill them. Those questions require local data on land transactions, utility

availability, and firm location. The value of the model lies in making assumptions explicit and in providing a benchmark against which later empirical corridor studies can be compared.

7. Policy Implications

Six implications follow from the scenario experiments. They are offered as hypotheses for planners to test with local data rather than as prescriptions.

First, the access regime should be fixed before alignment finalisation. Limiting entry to planned interchanges, and spacing those interchanges to match the intended settlement hierarchy, is the cheapest instrument available. Second, a statutory setback and protected strip along the alignment, as represented in S1, should be paired with service-road controls so that frontage development cannot recreate open access. Third, interchange areas should be designated in advance as growth nodes through master-plan zoning, with infrastructure and land-use rules prepared before land values rise.

Fourth, land policy should share gains and reduce speculation. Instruments such as land pooling and town-planning schemes allow public agencies to assemble land, provide infrastructure, and return serviced plots, thereby capturing part of the uplift that corridors create. Fifth, productive farmland, including irrigated and wastewater-irrigated belts, should be mapped and given agricultural zoning, since the evidence shows that conversion is largely irreversible (Gumma et al., 2017). Sixth, the Hyderabad Metropolitan Development Authority, the National Highways Authority of India, and district administrations should share a common satellite-based monitoring system, with annual change detection along both ring roads, so that unplanned conversion is identified early.

8. Limitations and Future Research

Several limitations bound the interpretation. First, the model operates on a synthetic landscape that preserves the geometry of the corridors but not real terrain, soils, tenure, or settlement patterns. Second, coefficients are assumed rather than estimated, and different values would change magnitudes, although the ordering of scenarios is expected to be robust because it follows from the sign of the corridor terms. Third, demand is held constant across scenarios, whereas highways may induce additional demand (Duranton & Turner, 2012); the reported effects on location are therefore likely to be conservative with respect to total conversion. Fourth, only farmland-to-built-up conversion is modelled, without distinguishing residential, industrial, and logistics uses. Fifth, several corridor attributes rely on web-based planning reports that may be revised.

Future work should replace the synthetic landscape with classified multi-temporal imagery for the ORR and radial corridors, estimate the utility coefficients by logistic regression, test the propositions with spatial econometric methods, and validate the model out of sample using allocation and quantity disagreement measures (Pontius & Millones, 2011). Qualitative work on land markets, farmers' sale decisions, and the role of intermediaries along the RRR would also illuminate the mechanisms that the model treats as a single latent utility.

9. Conclusion

This paper examined how highways and regional ring roads shape peripheral land-use transformation in Telangana. Published evidence shows that the Hyderabad region's built-up area roughly doubled between 2005 and 2016, with sprawl extending beyond the ORR. A calibrated scenario model, run on a synthetic

landscape, shows that the proposed RRR would redistribute growth outward, and that the magnitude of that redistribution depends heavily on access design. Open access draws about forty-six times more development within two kilometres of the alignment than the baseline and increases leapfrog development to about 14 per cent of conversions, whereas controlled access with a protected strip moderates but does not remove the effect. Planning documents for the RRR should therefore treat access design as a primary decision variable rather than a detail settled after alignment.

The central message is that corridor design is land policy. A ring road is not only a transport asset but also a rule for where, and how cheaply, land can be reached. Decisions on interchange spacing, access control, setbacks, and zoning will help determine whether the RRR produces a set of serviceable growth nodes or a diffuse belt of scattered development on productive farmland. Because these decisions remain open while the project is at the planning stage, the window for acting on them is now. Empirical validation with imagery and land-market data should follow, but the direction of the evidence is clear enough to inform early planning.

REFERENCES:

1. Alonso, W. (1964). *Location and land use: Toward a general theory of land rent*. Harvard University Press.
2. Anas, A., Arnott, R., & Small, K. A. (1998). Urban spatial structure. *Journal of Economic Literature, 36*(3), 1426–1464.
3. Angel, S., Parent, J., Civco, D. L., Blei, A., & Potere, D. (2011). The dimensions of global urban expansion: Estimates and projections for all countries, 2000–2050. *Progress in Planning, 75*(2), 53–107. https://doi.org/10.1016/j.progress.2011.04.001
4. Asher, S., & Novosad, P. (2020). Rural roads and local economic development. *American Economic Review, 110*(3), 797–823. https://doi.org/10.1257/aer.20180268
5. Banerjee, A., Duflo, E., & Qian, N. (2020). On the road: Access to transportation infrastructure and economic growth in China. *Journal of Development Economics, 145*, Article 102442. https://doi.org/10.1016/j.jdeveco.2020.102442
6. Baum-Snow, N. (2007). Did highways cause suburbanization? *The Quarterly Journal of Economics, 122*(2), 775–805. https://doi.org/10.1162/qjec.122.2.775
7. Bhatta, B. (2010). *Analysis of urban growth and sprawl from remote sensing data*. Springer.
8. Brueckner, J. K. (2000). Urban sprawl: Diagnosis and remedies. *International Regional Science Review, 23*(2), 160–171. https://doi.org/10.1177/016001700761012710
9. Duranton, G., & Turner, M. A. (2012). Urban growth and transportation. *The Review of Economic Studies, 79*(4), 1407–1440. https://doi.org/10.1093/restud/rds010
10. Ellis, P., & Roberts, M. (2016). *Leveraging urbanization in South Asia: Managing spatial transformation for prosperity and livability*. World Bank. https://doi.org/10.1596/978-1-4648-0662-9
11. Ghani, E., Goswami, A. G., & Kerr, W. R. (2016). Highway to success: The impact of the Golden Quadrilateral project for the location and performance of Indian manufacturing. *The Economic Journal, 126*(591), 317–357. https://doi.org/10.1111/ecoj.12207

12. Gumma, M. K., Mohammad, I., Nedumaran, S., Whitbread, A. M., & Lagerkvist, C. J. (2017). Urban sprawl and adverse impacts on agricultural land: A case study on Hyderabad, India. *Remote Sensing, 9*(11), Article 1136. https://doi.org/10.3390/rs9111136
13. Hosmer, D. W., Lemeshow, S., & Sturdivant, R. X. (2013). *Applied logistic regression* (3rd ed.). Wiley.
14. Hyderabad Metropolitan Region. (n.d.). In *Wikipedia*.
15. https://en.wikipedia.org/wiki/Hyderabad_Metropolitan_Region
16. McGee, T. G. (1991). The emergence of desakota regions in Asia: Expanding a hypothesis. In N. Ginsburg, B. Koppel, & T. G. McGee (Eds.), *The extended metropolis: Settlement transition in Asia* (pp. 3–25). University of Hawaii Press.
17. The Metro Rail Guy. (n.d.). *Hyderabad Regional Ring Road: Information and status*. https://themetrorailguy.com/nhai-hyderabad-regional-ring-road-information-route-map-status/
18. Mills, E. S. (1967). An aggregative model of resource allocation in a metropolitan area. *The American Economic Review, 57*(2), 197–210.
19. Muth, R. F. (1969). *Cities and housing: The spatial pattern of urban residential land use*. University of Chicago Press.
20. NBM&CW. (n.d.). *MoRTH expedites ₹16,003-cr RRR project in Telangana*. https://www.nbmcw.com/news/roads-highways/morth-expedites-rs16-003-cr-rrr-project-in-telangana.html
21. Office of the Registrar General & Census Commissioner, India. (2011). *Census of India 2011: Provisional population totals*. Ministry of Home Affairs, Government of India.
22. Outer Ring Road, Hyderabad. (n.d.). In *Wikipedia*. https://en.wikipedia.org/wiki/Outer_Ring_Road,_Hyderabad
23. Pontius, R. G., Jr., & Millones, M. (2011). Death to Kappa: Birth of quantity disagreement and allocation disagreement for accuracy assessment. *International Journal of Remote Sensing, 32*(15), 4407–4429. https://doi.org/10.1080/01431161.2011.552923
24. Redding, S. J., & Turner, M. A. (2015). Transportation costs and the spatial organization of economic activity. In G. Duranton, J. V. Henderson, & W. C. Strange (Eds.), *Handbook of regional and urban economics* (Vol. 5, pp. 1339–1398). Elsevier. https://doi.org/10.1016/B978-0-444-59531-7.00020-X
25. Seto, K. C., Fragkias, M., Güneralp, B., & Reilly, M. K. (2011). A meta-analysis of global urban land expansion. *PLOS ONE, 6*(8), Article e23777. https://doi.org/10.1371/journal.pone.0023777
26. Verburg, P. H., Schot, P. P., Dijst, M. J., & Veldkamp, A. (2004). Land use change modelling: Current practice and research priorities. *GeoJournal, 61*(4), 309–324. https://doi.org/10.1007/s10708-004-4946-y
27. Verburg, P. H., Soepboer, W., Veldkamp, A., Limpiada, R., Espaldon, V., & Mastura, S. S. A. (2002). Modeling the spatial dynamics of regional land use: The CLUE-S model. *Environmental Management, 30*(3), 391–405. https://doi.org/10.1007/s00267-002-2630-x
28. von Thünen, J. H. (1966). *Von Thünen's isolated state* (C. M. Wartenberg, Trans.; P. Hall, Ed.). Pergamon Press. (Original work published 1826)